advantaged mechanical design wherein the local edge temperature is reduced near an area of high thermal strain. The capillary features may be used to control or tailor the process performance as measured in conversion and selectivity for a given capacity or flow rate per unit volume. The features may also be used to minimize mechanical strains in high strain regions of the apparatus by reducing the local heat release and thus reduce the resulting temperature gradient.

[0244] Methods for Wash-Coating to Produce Uniform or a Tailored Profile

[0245] 1) Using Capillary Features

[0246] To retain a liquid (either catalyst precursor or other). The fluid is filled within a microchannel or an array of parallel microchannels and then drained after leaving behind fluid within the capillary features on the wall. The fluid may then be dried or drained to leave behind active agent on the walls. The fluid may be aqueous based or comprising a solution of solid nanoparticles, polymeric, or any liquid coating composition.

[0247] Capillary Feature Retention Modeling

[0248] Capillary Feature Without Gravity Force

[0249] **FIG. 7** shows six stages of filling a capillary niche, named case I through VI. The niche is shown oriented upward for convenience. The radii of curvature of the surfaces are depicted as though constant across the surface in each case, as though gravity was unimportant.

[0250] In case I, the hydrostatic angle of contact θ is controlled by thermodynamics; i.e., $\theta=\alpha$, where α is the thermodynamic contact angle, a function of the composition of the liquid, the solid, and the vapor. As one adds more liquid, eventually the surface rises to the point the line of contact reaches the corner, case II. The hydrostatic angle of contact is still equal to the thermodynamic contact angle. Now as one adds still more liquid, the surface cannot maintain the thermodynamic contact angle because of the discontinuity in the orientation of the surface at the corner. Instead, the line of contact remains at the corner while the hydrostatic angle of contact increases, as show in Case III. Eventually this angle becomes a right angle and the niche is filled. Adding still more liquid causes the surface to expand beyond the top of the niche, Case IV. The pertinent hydrostatic angle of contact is now measured relative to the surface outside the niche; this angle is denoted θ'. For Case IV, $\theta'<\alpha$. Adding still more liquid increases the curvature of the surface until $\theta'=\alpha$, Case V. Adding still more liquid now causes the point of contact to move beyond the corner of the niche and the liquid spreads onto the surface outside the niche, Case VI. The surface shape once again maintains $\theta'=\alpha$. Thus, for Cases I or VI, the boundary condition on the shape of the surface is the slope, set by the thermodynamic contact angle. The derivative of y is fixed and the location is found from solving an ODE. For Cases II through V, the boundary condition is that the surface is bounded by the corners of the niche. The value of the y is fixed at a location and the derivative (slope) is found from solving an ODE.

[0251] Capillary Features with Gravity (2-D Model)

[0252] Now orient the niche so it faces horizontally to the right (**FIG. 8**) and do not ignore the effect of gravity.

[0253] First, we need to relate the capillary pressure difference to the shape of the surface.

[0254] Consider a surface described by the function y=f(x, z) (see **FIG. 8**). Next consider the 2-dimensional case where in fact y does not vary with x. That is, the plane z=constant intersects the surface along a straight line, while the plane x=constant intersects the plane along a line in the x-plane described by

$$y=y(z)$$

[0255] If near some value of z this line is locally a circular arc, then locally it is described by

$$y^2+z^2=R^2$$

[0256] where R is the radius of curvature. Differentiating once with respect to z gives

$$yy'+z=0$$

[0257] Differentiating again gives

$$y'^2+yy''+1=0$$

[0258] Also, substituting the first differentiation into the formula for the arc gives

$$y^2+(-yy)^2=R^2$$

[0259] Solving for y gives

$$y=\pm\frac{R}{(1+y'^2)^{1/2}}$$

[0260] where the sign depends on the arrangement of the coordinate system and within it the convexity or concavity of the arc. Substituting into the second differentiation gives

$$y'^2+1\pm\frac{R}{(1+y'^2)^{1/2}}y''=0$$

[0261] Solving for 1/R gives

$$\frac{1}{R}=\pm\frac{y''}{(1+y'^2)^{3/2}}$$

[0262] where the actual sign depends on the convexity or concavity of the arc.

[0263] This radius R describes the curvature in the y-z plane. If as assumed above there is no variation of y with x, then the radius of curvature in the y-x plane is infinite. Then the capillary pressure difference across the curved surface is

$$\Delta p=\frac{\sigma}{R}=\pm\sigma y''(1+y')^{-3/2}$$

[0264] ΔP=Pressure drop between liquid and gas above it.

[0265] σ=Surface tension

[0266] Besides capillary forces, other surfaces forces like chemical coating may also contribute to the retention of